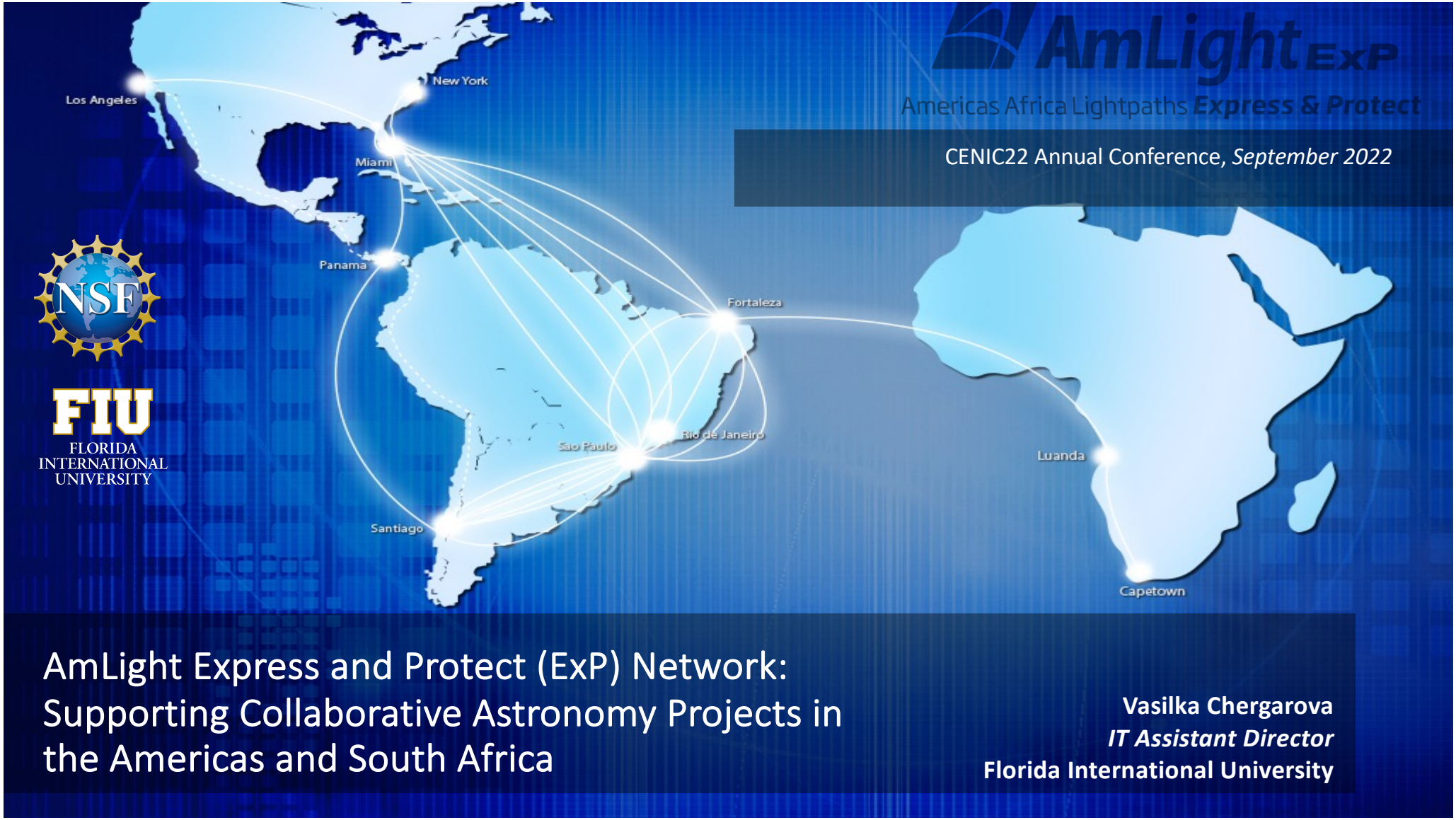

AmLight Express and Protect (ExP) Network: Supporting Collaborative Astronomy Projects in the Americas and South Africa

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IT Assistant Director
Florida International University

Outline

- Astronomy Projects in South America and Africa
- What is AmLight?
- Network Connectivity
- Other activity with CENIC
- Conclusion

South America Astronomy projects

There are over 84 astronomical observatories in South America that feature telescopes used for astronomy research and 65 are located in Chile due to the dry climate.

Chile hosts about 55% of the world astronomical observation capacity

- In operation: Magellan Telescope, GEMINI, VLT, ACT, ALMA , Polarbear, CLASS, and more
- In construction: Simmons Observatory, Vera Rubin Observatory, GMT, ELT
- Projected: TAO, FYST (a.k.a. CCAT), CTA-South

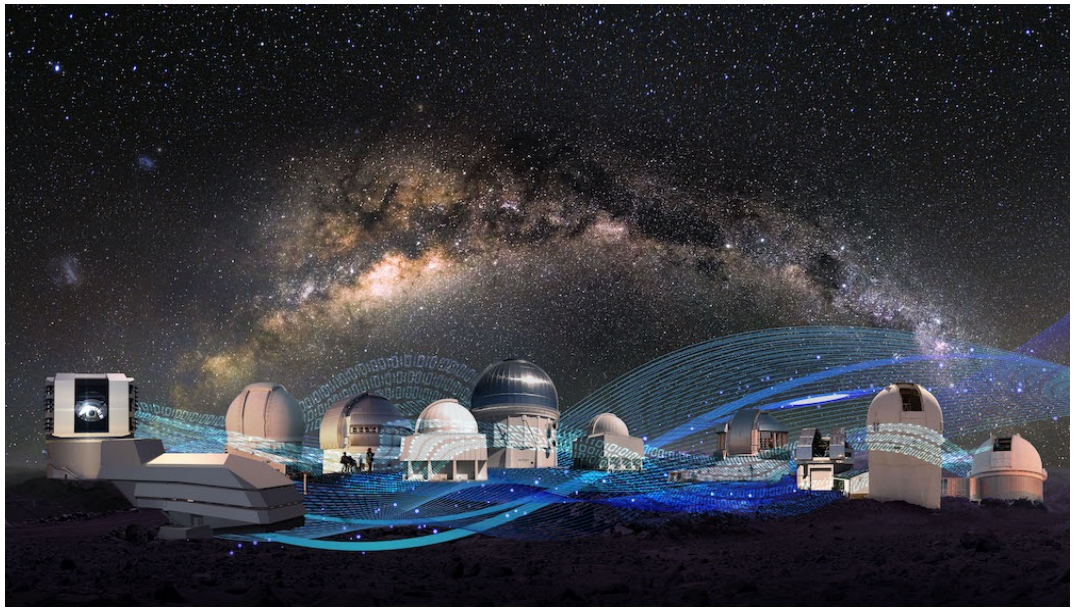
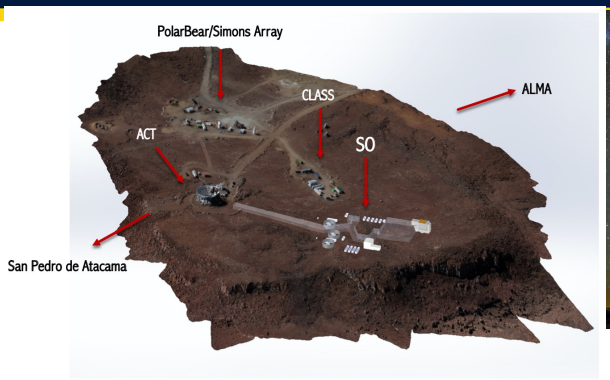


Photo montage of the facilities of the NOIRLab. Photo credit: NOIRLab/AURA/NSF/P. Marenfeld[1]

[1] NSF's National Optical-Infrared Astronomy Research Laboratory (NSF's NOIRLab) is the preeminent US national center for ground-based, nighttime optical and infrared astronomy. https://nationalastro.org/about/

South America Astronomy projects

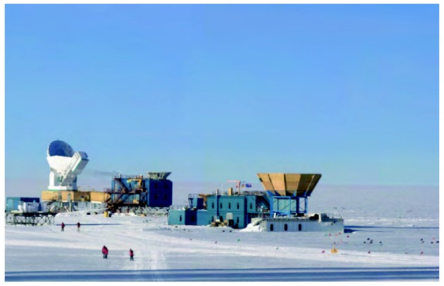
Vera Rubin Observatory and Legacy Survey of Space and Time (LSST)



Simons Observatory in the Atacama Desert /Chile

NSF/AURA: Gemini South on Cerro Pachón/Chile (left) and Gemini North on Maunakea/Hawai'i (right)

Atacama Large Millimeter/submillimeter Array (ALMA)



Left: the CMB telescope at South Pole Station in Antarctica. Right: CMB telescopes at Cerro Toco in the Chilean Andes (https://www.nsf.gov/mps/ast/aaac/cmb_s4/report/CMBS4_final_report_NL.pdf)

Africa Astronomy projects

South African Astronomical Observatory (SAAO) is the national center for optical and infrared astronomy in South Africa

- SAAO telescopes includes BiSON, KELT-South, LCOGT, MONET, Solaris, SuperWASP-South , and SALT
- More Karoo Array Telescope (MeerKAT)
- Square Kilometer Array (SKA)

More Karoo Array Telescope (MeerKAT)
https://www.ska.ac.za/science-engineering/meerkat/about-meerkat/

Square Kilometre Array (SKA):
https://www.skatelescope.org

The Southern African Large Telescope (SALT)
https://www.salt.ac.za/

South American-African Astronomy Coordination Committee (SA3CC)

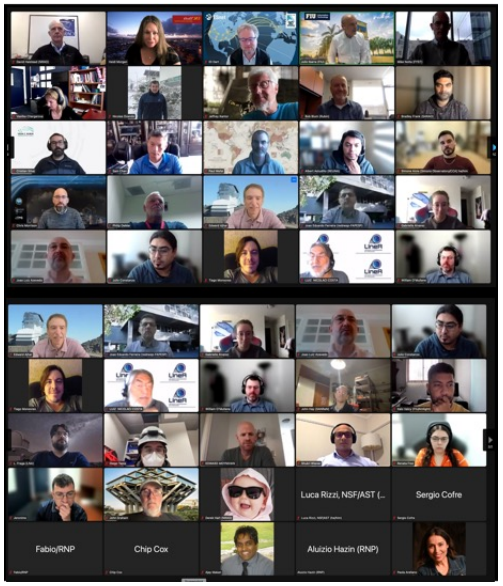
SA3CC was formed in 2011 based on WHREN-LILA collaborative project between NSF, FIU, CENIC, rednesp (formally known as ANSP), and FAPESP (2005-2010)

- SA3CC is comprised of representatives from the various
  - Astronomy projects operating observatories in South America and Africa
  - The AmLight project, and operators of the research and education networks in South America, Africa and in the U.S.
- SA3CC Goals
  - To provide input and advice to the AmLight Principal Investigator on program and network needs
  - To serve as a venue for coordinating the network needs of astronomical projects and institutions
  - To improve their resource planning and implementation of operational connections between these distant facilities and users in the continental US

2013

2017

2019



2022

AmLight ExP
Americas Africa Lightpaths Express & Protect

What is AmLight-ExP?

- An International Research and Educational Network built to enable collaboration among Latin America, Africa, and the U.S.
- Supported by NSF, OAC, and the IRNC program under award # OAC-2029283 for 2021-2025
- Partnerships with R&E networks in the U.S., Latin America, Caribbean and Africa, built upon layers of trust and openness by sharing:
  - Infrastructure resources
  - Human resources

AmLight ExP
Americas Lightpaths Express & Protect
(NSF Award # OAC-2029283)

AmLight ExP
Americas Africa Lightpaths Express & Protect

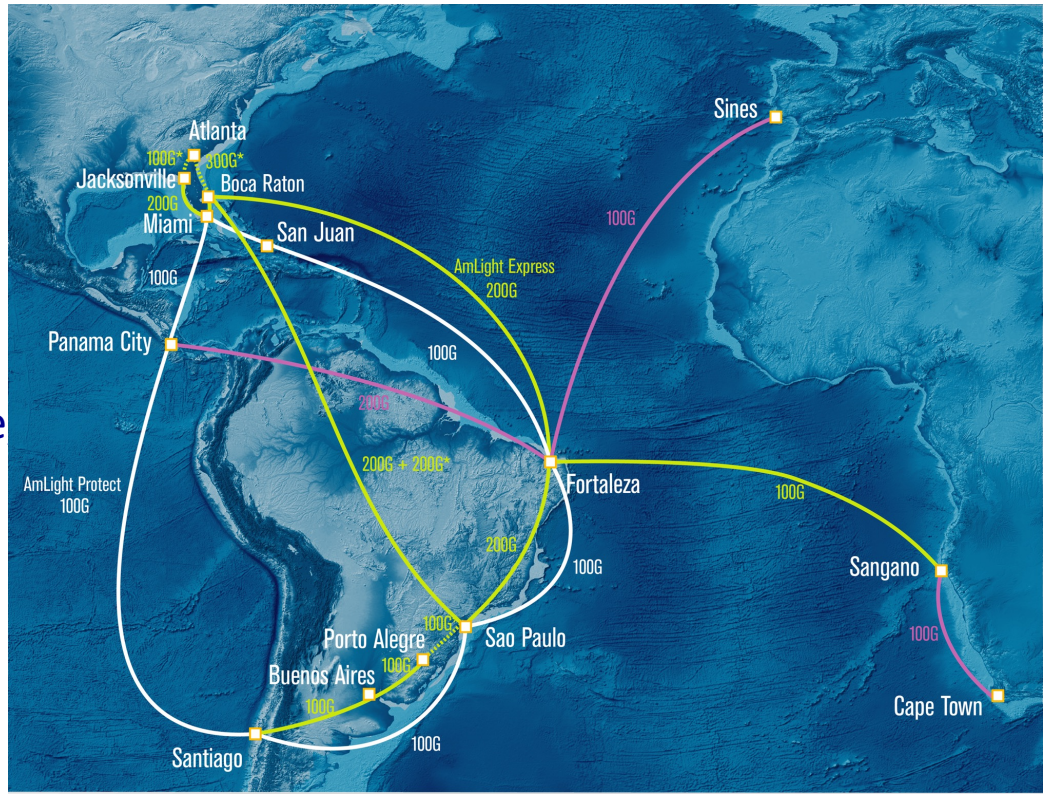
The AmLight-ExP Project Goals

- Vision:
  - Continue enabling collaboration among researchers and network operators in Latin America, Africa, and the U.S. by providing reliable, sustainable, scalable, and high-performance network connectivity and services.

- Focus (2021-2025):
  - Supporting Service Level Agreement (SLA)-driven science applications
  - Improving network visibility and management
  - Enabling integration between AmLight and network-aware science drivers
  - Adding new network and cloud services
  - Minimizing the human role in network operation

Network Connectivity

- 600Gbps of upstream capacity between the U.S. and Latin America, and 100Gbps to Africa
  - 2023: Add 200Gbps from Brazil to the U.S.
- 2+ Tbps of international connectivity
  - AmLight Express (green), AmLight Protected (white), plus waves provided by RedClara and SANReN/TENET (pink)
  - 2022: RedClara added 100G from Panama City to Fortaleza
- Network Access Points: Florida(3), Brazil(2), Chile Puerto Rico, Panama, and South Africa
  - 2022: AmLight is expanding to Atlanta, Georgia with 400Gbps of total capacity:
    - 300Gbps from Boca Raton to Atlanta
    - 100Gbps from Jacksonville to Atlanta
    - Dedicated connections to ESnet and FABRIC



* and dashed lines represent on going efforts

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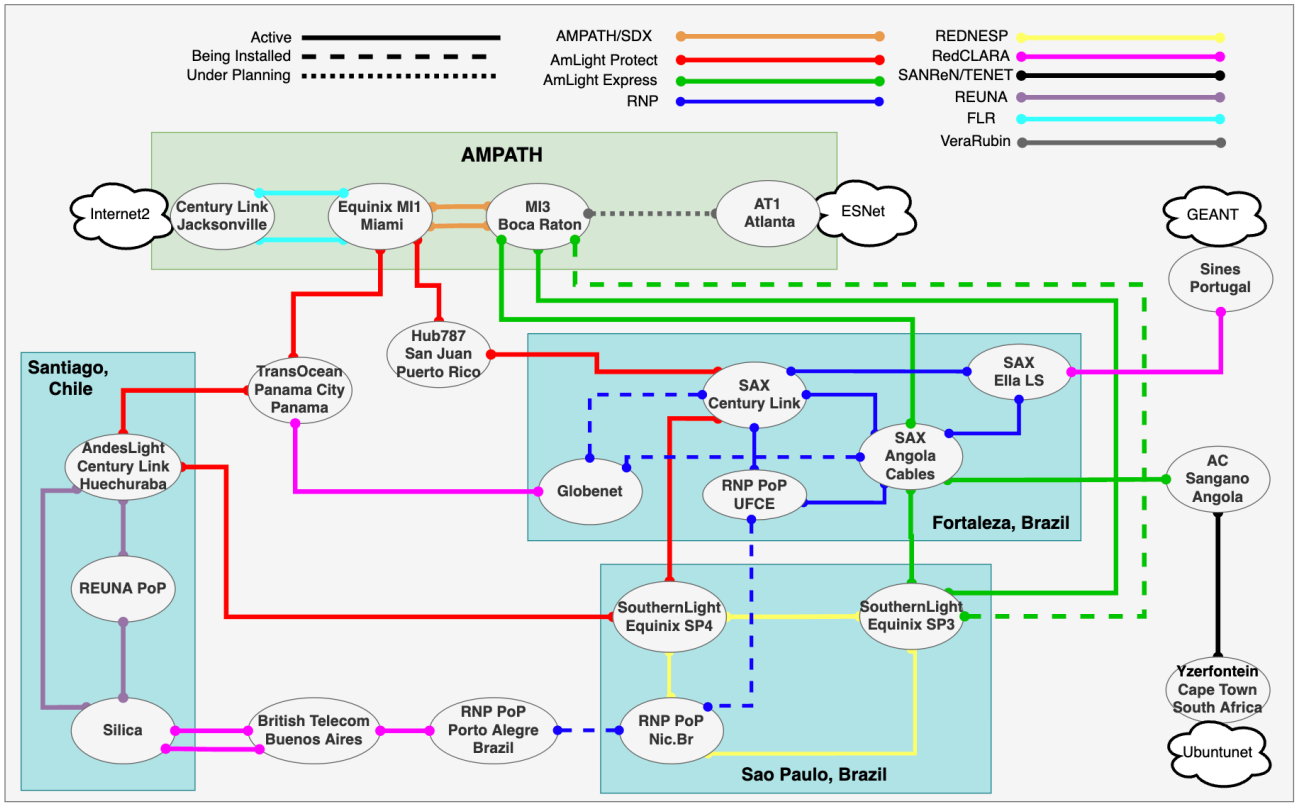
AmLight: Collaboration at its finest!



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AmLight: Site-to-Site Connectivity

	Florida/US	Georgia/US	Brazil	Chile	Panama	Puerto Rico	South Africa
Florida/US		400 Gbps	600 Gbps		100 Gbps	100 Gbps	100 Gbps
Georgia/US	400 Gbps						
Brazil	600 Gbps			300 Gbps	100 Gbps	100 Gbps	100 Gbps
Chile	100 Gbps		300 Gbps		100 Gbps		
Panama	100 Gbps		100 Gbps	100 Gbps			
Puerto Rico	100 Gbps		100 Gbps				
South Africa	100 Gbps		100 Gbps				

Green: New Installation

Blue: Upgrades Planned/In Motion

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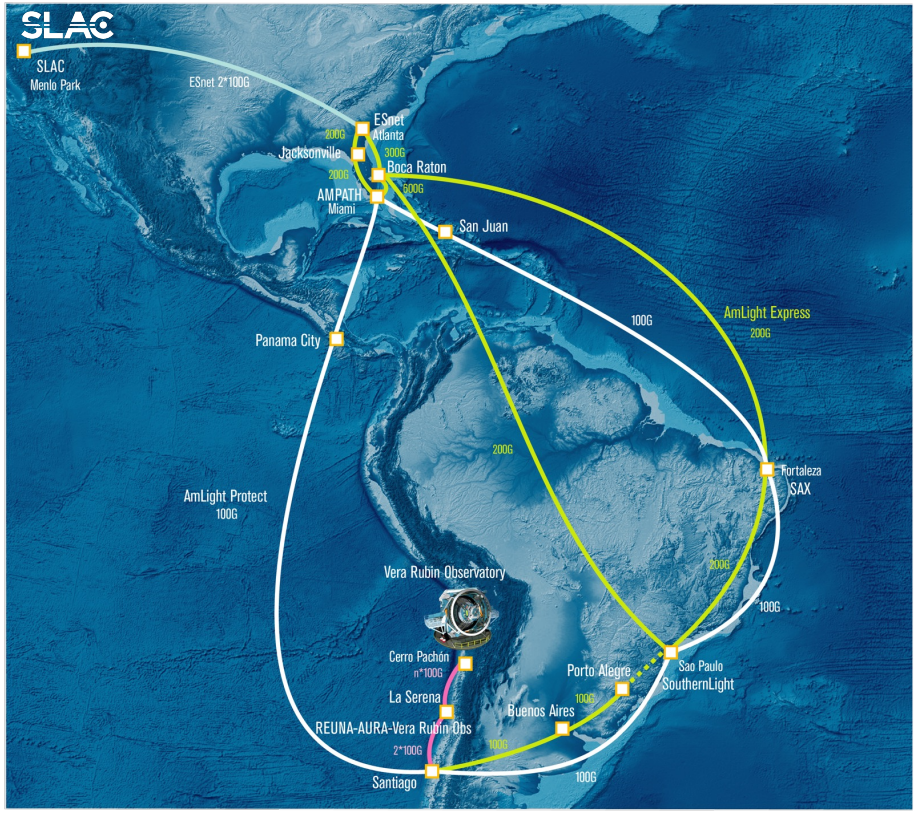
Use Case: Vera Rubin Observatory operation

- Vera Rubin is a large-aperture, wide-field, ground-based optical telescope under construction in northern Chile
- The 8.4 meter telescope will take a picture of the southern sky every 27 seconds, and produce a 13 Gigabyte data set
- Each data set must be transferred to the U.S. Data Facility at SLAC, in Menlo Park, CA, within 7 seconds, inside the 27-second processing window
- Challenges
  - High propagation delay in the end-to-end path
  - RTT from the Summit Station to the USDF is approximately 180+ ms
  - 0.001% of packet loss will compromise the Rubin Observatory application



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Vera Rubin Observatory Network Engineering Taskforce (NET)

- Multiple network operators have ongoing network-engineering efforts in place to support the Vera Rubin Observatory project. The NET was officially created in 2017 to support that effort.

- NET is comprised of representatives from multiple organizations and Research and Educational Networks
  - US: AURA, FIU/AmLight, Internet2, ESnet, SLAC, FermiLab, NCSA
  - Latin America: REUNA, RedCLARA, RNP, REDNESP
  - Europe: IN2P3, RENATER, GEANT, and Jisc

- NET Goals
  - To coordinate the steps to interconnect all efforts towards a manageable, cost-effective, secure and scalable end-to-end network infrastructure

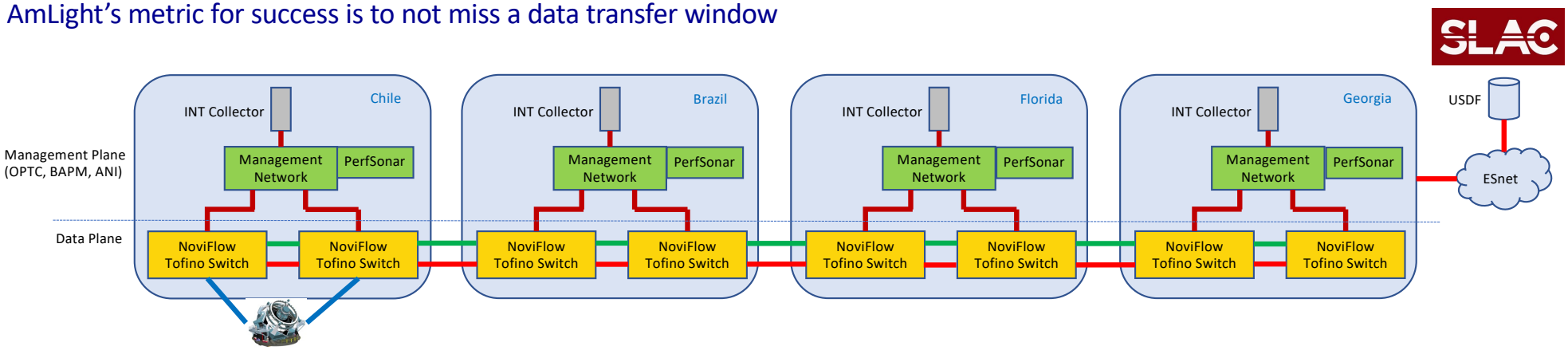
AmLight increasing automation

	Automatic	Automation	Closed-Loop Orchestration	Autonomic
Description	User runs a script to change a service or configuration	User runs a “playbook” to change multiple services and to configure multiple nodes at the same time	Orchestrator changes multiple services and node configurations. Nodes export new status and counters. Orchestrator monitors and reacts to the new state, then performs (or not) changes in a closed loop.	Application discovers assets. Configures devices from scratch based on policies and intents. Minimal to no user interaction. Resolution of conflicts defined by administrators
User Input	Scripts, inputs, topology, destination	Scripts, inputs, inventory	Scripts, inputs, inventories, policies/conditions/triggers	Policies and intents

AmLight ExP
Americas Africa Lightpaths Express & Protect

Instrumented for SLA-grade network resilience

- AmLight is instrumented for SLA-grade network resilience to support Vera Rubin
  - Express and Protect paths are instrumented with INT and PerfSonar
- AmLight's Management Plane
  - Processing telemetry report
  - Isolating and detecting traffic anomalies
  - Validating performance thresholds
  - Computing risk profiles of optical and IP layer metrics in a closed loop
  - Reacting to packet loss and packet performance in real-time
- AmLight's metric for success is to not miss a data transfer window



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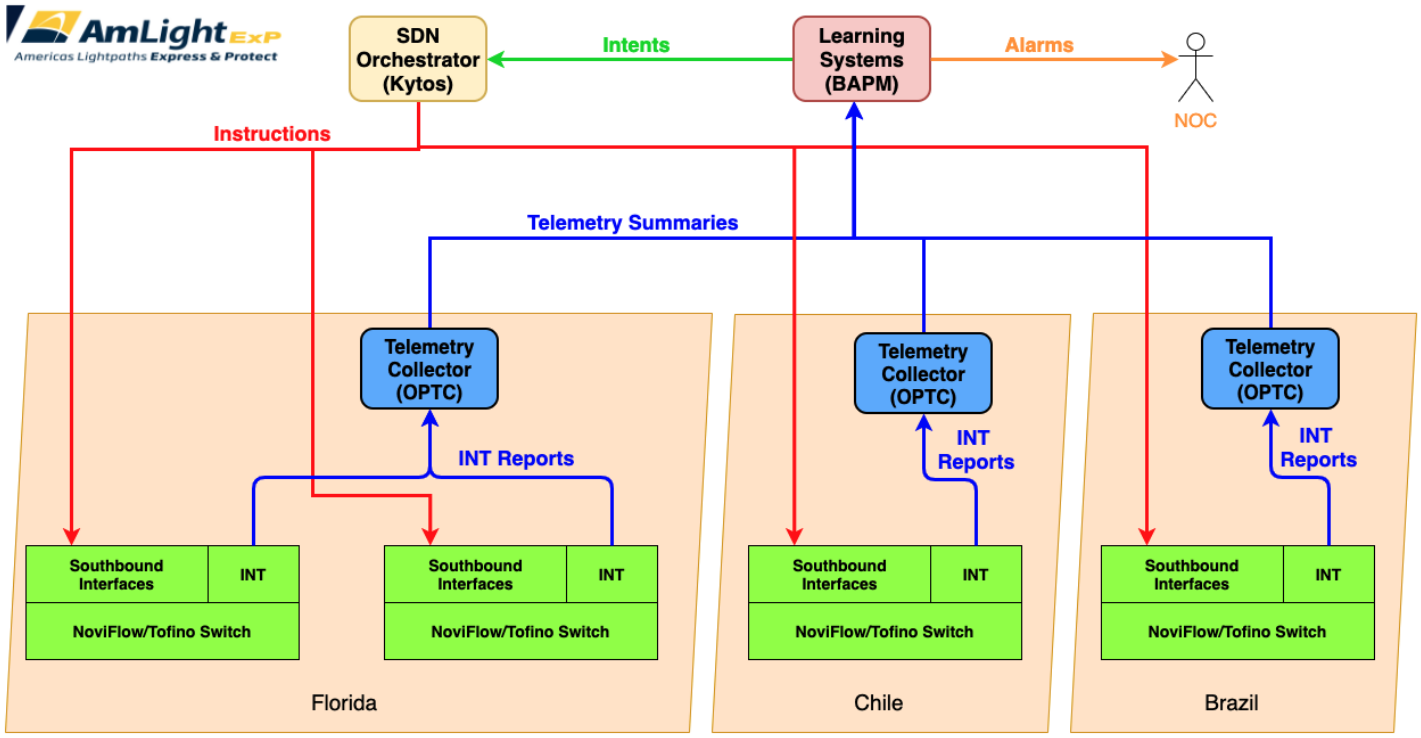
AmLight Use Case: Self-optimizing

Closed-loop network orchestration by

- Processing telemetry reports from the packet and optical layers
- Combined with learning algorithms

Roadmap: Traffic engineering the network:

- Year 2: < 5 seconds
- Year 3: < 2 seconds
- Year 4: < 1 second
- Year 5: < 500 ms



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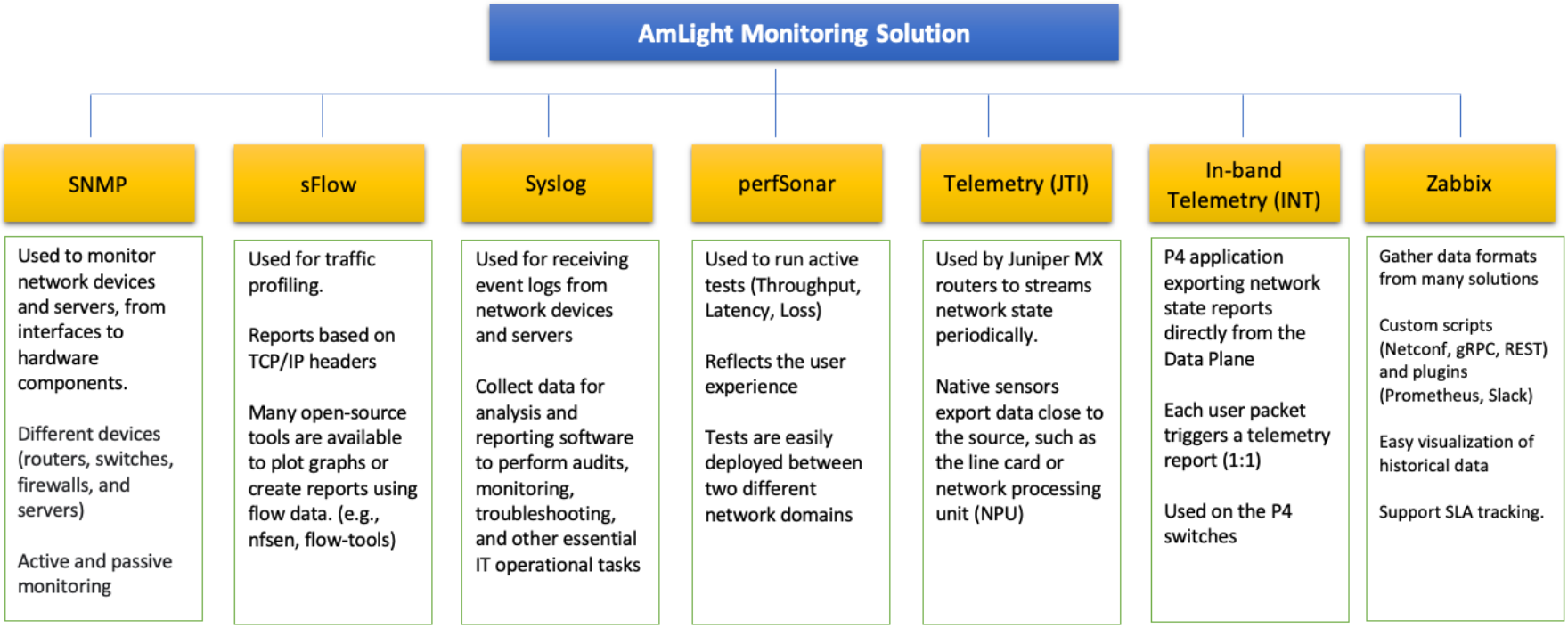
AmLight monitoring solution



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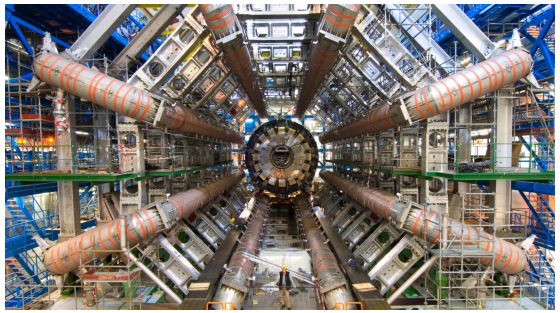
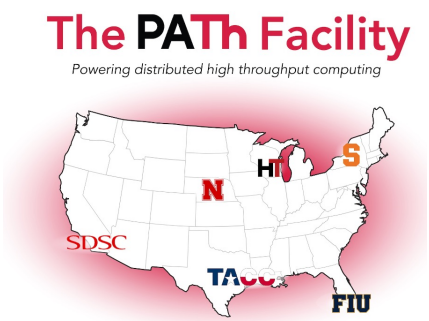
Other science communities supported on AmLight

- Large Hadron Collider Open Network Environment (LHCONE)
- Open Science Grid (OSG)
- Partnership to Advance Throughput Computing (PATh)
- Event Horizon Telescope (EHT)
- Ground-based telescopes in Chile and South Africa

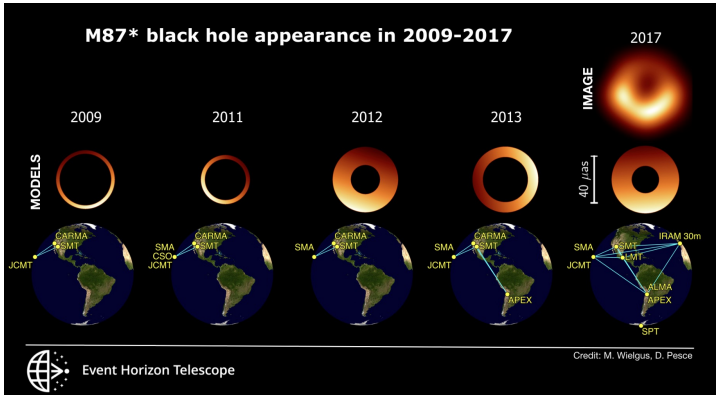


Large Hadron Collider (LHC); Credit: CERN

Institutions participating in the OSG Compute Federation. Credit: Open Science Grid



PATh Facility sites. Credit: Josephine Watkins



EHT array of telescopes in 2009-2017. Credit: M. Wielgus, D. Pesce & the EHT Collaboration

AmLight ExP
Americas Africa Lightpaths Express & Protect

Cooperating with CENIC on other SDN/SDX projects

The IRNC SDXs inter-collaboration was initiated in 2018 and the bi-weekly meetings are currently hosted by CENIC. It includes representatives from AtlanticWave-SDX, Pacific Wave SDX, and StarLight SDX.

- Goals:
  - Commitment for inter-operability across participating exchanges
  - Bi-weekly calls to discuss requirements for inter-operability and sharing of progress and evolution of SDX activities
- SDN/SDX enables additional collaborations such as
  - Hosting GEN4 node at AmLight/AMPATH to support the PRP/Nautilus project
  - DTNs as appliances within the exchange points
  - perfSONAR implementations
  - Dashboard reflecting both memory-to-memory and disk-to-disk performance
  - Exploring different data-movement tool sets (e.g., FDT, mdtmFTP, GridFTP)
  - Supporting Science Drivers from various efforts across the US and internationally (e.g., LHC, Vera Rubin Observatory)

Conclusion

AmLight has many links and multiple paths connecting its sites to support astronomy projects:

- From Chile to Jacksonville, there are more than 25 possible paths to take
- With the new architecture, we expect to properly load balance network services across links, while respecting user constraints and requirements

AmLight will handle any SLA-driven packet-loss-intolerant and sub-minute-response-time-expected science application:

- With per-packet telemetry and sub-second network profiling capacities, AmLight will be prepared to react to network conditions under 1 second
- With optical telemetry, AmLight will anticipate issues with the substrate and steer traffic out of the substrate before adverse events happen

AmLight engineering team is able to focus on engineering and new services rather than manual activities:

- With the closed loop control, some time-consuming operational activities will be performed without human intervention
- More software developers are automating routines

THANK YOU

NSF

FIU FLORIDA INTERNATIONAL UNIVERSITY

AMLIGHT RESEARCH · EDUCATION COLLABORATION

AMPATH PATHWAY OF THE AMERICAS

USC

AmLight ExP International Distributed Exchange Point

AtlanticWave SDX INTERNATIONAL DISTRIBUTED SOFTWARE-DEFINED EXCHANGE

AtlanticWave-SDX 2.0

AtlanticWave-SDX 2.0: A Distributed Experimental SDX Supporting Research, Experimental Deployments, and Interoperability Testing at Global Scale

Goals:

- To build a distributed SDX between the Americas and Africa (NSF award #2029278)
- Building a distributed intercontinental experimental SDX by leveraging Open Exchange Points (OXPs) connected to AmLight ExP
- The project also includes collaboration with the Open Science Grid (OSG) and Pegasus workflow management system.

To enable domain scientists to reserve network resources through a multi-domain SDX by

- Simplifying the interface for domain scientists to request network resources
- Providing interfaces to program the forwarding plane to respond to application requirements

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